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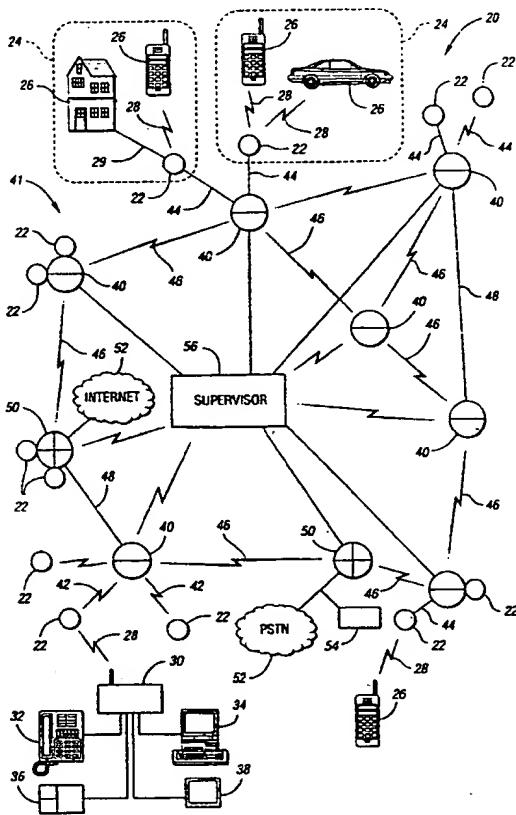
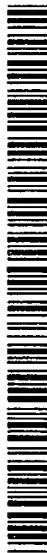
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(54) Title: CELLULARIZED PACKETIZED VOICE AND DATA



(57) Abstract: Distributed routing provides a robust, scalable communication system free of bottlenecks associated with traditional wireless systems. The system (20) includes subscriber units (26) sending and receiving information packets using wireless communication links (28). The system (20) also includes access points (22) with each access point (22) forming a coverage area (24) for exchanging information packets with subscriber units (26) within the coverage area (24). The system (20) further includes distribution points (40) receiving packets from access points (22). Distribution points (40) form a distributed routing network (41). Each distribution point (40) receives an information packet for distribution to a specified destination. If the destination is to a subscriber unit (26) within the coverage area (24) of the access point (22) in communication with the distribution point (40), the information packet is forwarded to the access point (22). Otherwise, the information packet is forwarded to one of the additional distribution points (40).

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CELLULARIZED PACKETIZED VOICE AND DATA**TECHNICAL FIELD**

The present invention relates to routing and delivery of information packets in wireless communication systems handling a plurality of information types.

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BACKGROUND ART

Communication systems are increasingly required to provide a wide range of services, including different forms of information communicated with different communication characteristics. Information forms include voice, data, video, telemetry, and the like. Communication characteristics include quality, 10 latency, reliability, cost, availability, portability, and the like. Infrastructure such as telecommunication systems, the Internet, and cable systems exist to provide long-haul routing and information content sourcing. However, difficulty remains in delivering this information to customers. This is particularly the case if the customer is located in a rural location, is communicating through portable equipment, or is 15 mobile.

Traditionally, communication service providers have relied on copper wire or coaxial cable to connect distribution sites and subscriber premises. However, increases in the number of users, number and type of communication devices per user, and the information rate per device has strained the ability for 20 traditional communication systems to provide the necessary bandwidth and flexibility. Various technologies including digital subscriber line (DSL) and video modems offer broadband access to the subscriber over existing copper or coaxial loop technologies. Fiber-to-the-home offers broadband access through additional wireline connections. While each technology has broadband delivery properties, 25 each is subject to physical and signaling limitations that restrict availability in certain locations and for certain applications.

One wireline technology is very-high-data-rate DSL (VDSL). A typical installation implements a hybrid local loop. Information packets are received and routed by a central office using ATM virtual circuits. The packets are sent from the central office over fiber-to-the-neighborhood (FTTN) to local optical network units (ONUs). Each ONU connects to several customer premises over copper, such as unshielded twisted pair (UTP). A network interface device (NID) on the customer premises may format the information for customer premises equipment and electrically isolate the customer premises from the VDSL network.

VDSL services may be symmetric or asymmetric. For example, downstream rates to the subscriber are typically 51.84 Mbps for UTP loops of 300 meters, 25.92 Mbps at 1,000 meters, and 12.95 Mbps at 1,500 meters. Upstream rates may fall into three classes, 1.6-2.3 Mbps, 19.2 Mbps, or equal to the downstream rate if permitted by class of service and available bandwidth.

There are several problems with current VDSL installations. First, since all packet routing takes place at a central office, the central office is a critical component to the system. If the central office fails, the entire area covered by the central office is without service. Further, the central office may become a bottleneck limiting the number of customers within the area that may be provided with VDSL service.

A second problem with current VDSL installations is the lack of ability to service all customers supported by the central office. Central offices are geographically located based on providing standard telephone services (POTS). In heavily populated areas, the coverage area of each central office may include more potential VDSL customers than the central office can support. In sparsely populated areas, potential VDSL customers are located at too great a distance from the central office to make VDSL services economically feasible.

A third problem with current VDSL installations is the ability to provide customers with a predictable level of service. The length, type, gauge, and quality of copper cabling connecting a VDSL customer and the central office is the

predominant factor in determining the information rate available to the customer. Often, the copper loop was designed for only POTS service. Unshielded cable is typical. Wire of different gauges along the loop is not uncommon. Further, unterminated bridged taps are often spliced into the loop to increase the flexibility 5 of the copper plant. Hence, neither the customer nor the service provider often knows the ultimate performance level until after the VDSL connection is made and tested.

Another wireline technology is broadband delivery for video signals. A central office receives or generates video information for distribution to 10 subscribers. This central office may be the same central office used for VDSL and POTS services or may be a separate central office for a given geographic area. The central office routes the video information to video distribution centers (VDCs) over distribution lines. Each VDC serves subscribers in a subset of the geographic area covered by the central office. Customer premises may be connected to the VDC 15 over twisted pair, fiber or, more commonly, coaxial cable. Video signals may be received by a set-top box, a gateway, a decoder or transmitter incorporated into the receiver, or the like. Video signals may be broadcast from the central office, with each channel occupying bandwidth in the distribution line at all times. Video signals may also be switched, with only those signals requested by a subscriber being 20 transmitted on the distribution line.

Many problems with video distribution networks are similar to difficulties experienced by VDSL systems. The central office presents both a critical component and a potential bottleneck. Because video distribution networks were typically designed for one-way distribution of video signals, they provide highly 25 asymmetrical communication paths. Also, customer equipment designed for video display is often incompatible with digital data equipment.

Wireless systems, such as PCS and cellular systems, offer an alternative to wireline services. Typically, wireless systems include a centralized mobile switching center (MSC) responsible for routing calls, tracking user locations, 30 billing information, and connectivity with other communication systems. The MSC

is connected to base station controllers (BSCs), each of which supports one or more base transceiver stations (BTSs). Each BTS supports one or more cells based on the number and configuration of antennas supported by the BTS. Customers communicate with the wireless system through radio telephones when the telephone 5 is within the coverage range of a cell. When a call is placed, a circuit-switched connection is established from the telephone, through the BTS and BSC, to the MSC. The MSC determines the destination and, if the destination is to another telephone within the wireless system, establishes a circuit-switched connection to the destination telephone. If the destination is outside of the wireless system, the MSC 10 routes the call to a service provider for the outside destination.

Cellular and PCS wireless systems have traditionally focused on voice. However, recent introduction of digital radio in both the 800 MHz and 1.9 GHz range permits low-speed data services, such as text messaging and one-way paging, to be implemented. Also, wireless modems implementing wireless 15 application protocols may be incorporated into hand-held devices such as lap top personal computers and personal digital assistants (PDAs). Such devices may offer access to the Internet at rates up to 19.2 kilobits per second.

Several problems have developed with traditional wireless systems. First, because all calls are processed by the central MSC, it can become a bottleneck 20 limiting the number of users supported. Second, if the MSC fails, the system becomes inoperative. Third, the BSC and BTS architecture is fairly rigid, requiring manual reconfiguration in the MSC when components are added or deleted. Fourth, circuit-switched channel connections establish an upper bandwidth, limiting communication rates. Fifth, bandwidth is wasted if the communication rate does not 25 reach the maximum established by the communication channel. Sixth, high-speed data and video applications are impractical on wireless telecommunication systems designed primarily for voice.

An alternative wireless communication system is the local multipoint distribution system (LMDS). In LMDS, an antenna broadcasts high-bandwidth 30 content to local receiving antennas. In the case of Internet access, the return path

is typically through slow telephone lines. LMDS, like wireline cable systems, is asymmetrical, making it best suited for distribution of one-way entertainment signals such as television. LMDS also typically operates at a high carrier frequency, requiring receiving antennas to be positioned in line-of-site with the transmitting 5 antenna.

What is needed is a communication system that provides voice, data, and video signals at rates appropriate for each user. The system should make efficient use of bandwidth, allocating only the bandwidth necessary for a particular communication. The system should be flexible, permitting automatic addition and 10 deletion of network components. The system should have distributed routing and service provisioning to prevent bottlenecks, permit scaling, and increase reliability and robustness. The system should support wireless communication, accommodating a wide variety of fixed, portable, and mobile user communication devices. The system should support high-speed symmetric and asymmetric communication for 15 applications such as Internet access, video conferencing, real-time distributed document sharing, video-on-demand, and the like.

DISCLOSURE OF INVENTION

The present invention provides a distributed network for communication and information access. A wide variety of services can be supported, including VDSL, video distribution, audio distribution, conferencing, 20 public service announcements, gaming, and the like. Various distribution formats are also supported, including fiber, hybrid, and wireless interconnectivity.

In carrying out the above objects and other objects and features of the present invention, a communication system is provided. The communication system 25 includes subscriber units sending and receiving information packets using wireless communication links. The system also includes access points. Each access point forms a coverage area for exchanging information packets with subscriber units within the coverage area. The system further includes distribution points. Each access point communicates with a distribution point. Each distribution point

communicates with at least one additional distribution point. Each distribution point receives information packets with a specified destination. If the information packet destination is to a subscriber unit within the coverage area of an access point in communication with the distribution point, the information packet is forwarded to the access point. Otherwise, the information packet is forwarded to one of the additional distribution points. Packets may contain one or more of voice, data, video, streaming audio, streaming video, and the like. Communication links may be symmetrical or asymmetrical.

In various embodiments of the present invention, access points may be in wireline or wireless connection with a distribution point. Also, distribution points may be interconnected by wireline or wireless means. Further, access points may be packaged with a distribution point or may be remotely located from the distribution point.

In another embodiment of the present invention, the communication system includes a communication system interface device capable of formatting information contained in the information packet to pass through a second communication system. A distribution point which receives an information packet for distribution within the second communication system sends the information packet to the second communication system interface device. The second communication system may include a wireless or wireline telecommunication system, a data network such as the Internet, or a video distribution system.

In a further embodiment of the present invention, a distribution point may include one or more of an asynchronous transfer mode switch, an Internet protocol router, an Ethernet router, or a time division multiplexed switch.

In yet other embodiments of the present invention, a quality error bit rate is established for each subscriber unit based on one or more of the location of the subscriber unit within the communication system, the class of service, the grade of service, and the rate of service.

In yet a further embodiment of the present invention, bandwidth is dynamically allocated when an information packet is exchanged between one of the plurality of subscriber units and one of the plurality of access points.

5 In a still further embodiment of the present invention, a distribution point includes a host digital terminal transmitting packets over optical fiber. The access point may include an optical network unit receiving packets over optical fiber and distributing packets to each subscriber unit over a digital subscriber loop.

10 In yet a still further embodiment of the present invention, the communication system includes at least one information distribution center. A distribution center may be a separate element. Also, a distribution point or an access point may function as a distribution center. The distribution center receives requests for information content from subscriber units and forwards those requests to at least one information supplier. Information packets comprising an information channel are forwarded to each subscriber unit requesting the channel. To accomplish this, 15 the distribution center replicates information packets for each subscriber units requesting the information channel.

20 A method for routing packets in a packetized communication system is also provided. Information is broken into a plurality of packets at a transmitting subscriber unit. The plurality of packets are transmitted to a distribution point in communication with the transmitting subscriber unit. Each packet is provided with an address identifying a destination distribution point within the communication system. In each distribution point along a path of distribution points to the destination distribution point, a determination is made as to which distribution point each packet will be forwarded based on the address. If the destination is a subscriber 25 unit in communication with the destination distribution point, when each packet is received at the destination distribution point it is forwarded to the destination subscriber unit where the information is assembled from the plurality of packets.

In an embodiment, the method further includes determining that the destination is to a receiver outside of the communication network. Each packet is

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In an embodiment, the method further includes determining that the destination is to a receiver outside of the communication network. Each packet is

provided with an address specifying a destination distribution point functioning as a gateway to a communication system supporting the receiver. Each packet is forwarded from the gateway distribution point to the communication system supporting the receiver.

5 In another embodiment, a request is received from a subscriber unit to access an information channel. Receiving a request from a subscriber unit may include determining that the requesting subscriber unit is within the coverage area of a distribution center or receiving a message requesting access from a subscriber unit. Transmission of the requested information channel is requested if no other 10 subscriber unit is receiving the requested information channel. A notation is made that the requesting subscriber unit is receiving the requested information channel. The method may also include determining that a subscriber unit is no longer accessing the information channel. Transmission of the information channel is canceled if no other subscriber unit is receiving the information channel. A notation 15 is made that the subscriber unit is no longer receiving the information channel.

A distribution point for use in a communication system comprising a plurality of networked distribution points is also provided. The distribution point includes at least one front end communication interface for communicating with an access point, the access point in wireless communication with subscriber units 20 currently assigned to the distribution point. The distribution point also includes at least one back end communication interface in communication with a back haul communication device. At least one back haul communication device sends packets to and receives packets from a back haul communication device in another of the networked distribution points. The distribution point further includes an intelligent 25 packet switching device that determines a destination for each received packet and determines if the destination is to a subscriber unit currently assigned to the distribution point. If so, the packet is sent to the destination subscriber unit. If the destination is not to a subscriber unit currently assigned to the distribution point, the switching device determines if the destination is to a subscriber unit currently 30 assigned to any other distribution point in the communication system. If so, another distribution point in back haul communication with the distribution point to which

the packet should be forwarded is identified and the packet is forwarded to the identified distribution point.

5 The above objects and other objects, features, and advantages of the present invention are readily apparent from the following detailed description of the best mode for carrying out the invention when taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

FIGURE 1 is a schematic drawing illustrating a portion of a communication system according to an embodiment of the present invention;

10 FIGURE 2 is a block diagram of a distribution point according to an embodiment of the present invention;

FIGURE 3 is a schematic drawing illustrating an implementation of a communication system according to an embodiment of the present invention;

15 FIGURE 4 is a schematic drawing illustrating an initial state for a communication system according to an embodiment of the present invention;

FIGURE 5 is a schematic drawing illustrating the addition of a second access point to the communication system of Figure 4 according to an embodiment of the present invention;

20 FIGURE 6 is a schematic drawing illustrating a hierarchical routing system using ATM/IP switches according to an embodiment of the present invention;

FIGURE 7 is a schematic drawing illustrating a network of distribution points routing packets based on forward equivalency classes according to an embodiment of the present invention;

FIGURE 8 is a schematic drawing illustrating forward equivalency class updating to track a moving subscriber unit according to an embodiment of the present invention;

5 FIGURE 9 is a schematic drawing illustrating distributed routing for high speed information services according to an embodiment of the present invention;

FIGURE 10 is a schematic drawing illustrating high speed information services provided without a hybrid local loop according to an embodiment of the present invention;

10 FIGURE 11 is a schematic drawing illustrating wireless high speed information services according to an embodiment of the present invention;

FIGURE 12 is a flow diagram illustrating reception of a request for a video channel by a distribution center according to an embodiment of the present invention; and

15 FIGURE 13 is a flow diagram illustrating termination of a request for a video channel by a distribution center according to an embodiment of the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

Referring to Figure 1, a schematic drawing illustrating a portion of a communication system according to an embodiment of the present invention is shown. A communication system, shown generally by 20, includes a plurality of access points 22 which may be, for example, a local radio access point (LRAP). Each access point 22 defines coverage area 24 such as, for example, a cell, covering a reception range of access point 22. Coverage area 24 may be formed from many independent sectors, as may result if access point 22 uses many unidirectional antennas, or may be a single region resulting from the use of an omnidirectional

antenna. Subscriber unit 26 within coverage area 24 may establish two-way wireless link 28 with access point 22. Subscriber unit 26 may also establish wireline link 29 with access point 22. Links 28, 29 may be symmetrical or asymmetrical. Subscriber unit 26 may be fixed or non-fixed and, if non-fixed, may posses varying 5 degrees of portability and mobility. Subscriber unit 26 may be a mobile telephone, a computer, a video receiver, an audio receiver, a two-way video conferencing station, a video game, an information kiosk, a remote sensor, a remote actuator, or any other suitable communication device.

Wireless link 28 may be any form of electromagnetic signaling not 10 confined to a wire or cable, including energy radiated by antenna as well as visible and invisible light. As will be appreciated by one of ordinary skill in the art, wireless link 28 may be implemented by any access technology, including CDMA, TDMA, FDMA, OFDM, analog, and the like. Modulation techniques that may be used with the present invention include FSK, BPSK, QPSK, m-ary QAM, FM, AM, 15 and the like. Further, the invention does not depend on modulation frequency or on the use of FDD or TDD. In a preferred embodiment, the access technology, frequency, and modulation method for establishing wireless link 28 are based, in part, on local geography, local regulations, noise and distortion sources, other operating wireless systems, cost, or any other suitable parameter. Subscriber unit 20 26 and access point 22 may establish wireless link 28 using a plurality of combinations of access technology, frequency, and modulation techniques.

Information transmitted on links 28, 29 may represent voice, data, 25 video, streaming audio, streaming video, or the like. Types of information include speech, facsimile, computer data, entertainment and informational audio and video, video game data, telemetry information, security information, and the like. If the information occurs as a continuous stream, subscriber unit 26 breaks the information into packets prior to packet transmission and reassembles the information stream from packets after packet reception. Any type of information that exists in packets or that may be packetized can be used with the present invention.

In an embodiment of the present invention, subscriber unit 26 may be implemented as part of terminal network controller 30 accepting inputs from and providing outputs to information sources including voice equipment 32, computing equipment 34, telemetry equipment 36, video equipment 38, or any other suitable communication equipment. Inputs to terminal network controller 30 may include serial data, parallel data, ISDN, standard telephone, xDSL, SR 1394, coaxial cable, twisted pair cable, optical fiber, or any other suitable communication protocol, method, or medium.

In an embodiment of the present invention, a quality error bit rate is established for each subscriber unit 26. This quality error bit rate may be based on the location of subscriber unit 26 within communication system 20, the class of service assigned to subscriber unit 26, the grade of service assigned to subscriber unit 26, the data or transmission rate of service assigned to subscriber unit 26, or any other suitable parameter. The quality error bit rate may be modified while subscriber unit 26 is within communication system 20 to reflect changing conditions such as noise, demand, connectivity, or any other suitable parameter. Applications providing services to subscriber unit 26 may adjust these services based on the quality error bit rate. For example, an application providing streaming audio and video may reduce the frame update rate as noise increases, guaranteeing successful transmission at a lower information rate. The information rate may be further reduced to provide only still pictures and audio if conditions continue to worsen. The information rate may also be automatically changed if subscriber unit 26 moves between coverage areas 24 with differing transmission capabilities or loads.

Control of the information rate may be achieved by having subscriber unit 26 monitor a signaling channel transmitted by access point 22 for each coverage area 24. This signaling channel informs subscriber unit 26 when to transmit information, how much information to transmit, the information transmission rate, and the like. The signaling channel may be controlled by a central supervisor, described below.

In an embodiment of the present invention, bandwidth on communication link 28 is only consumed when packets containing information are transmitted. For example, each subscriber unit 26 surrenders bandwidth on communication link 28 when not sending or receiving an information packet.

5 Packets to be transmitted are queued based on order of arrival, priority, a combination of arrival order and priority, or the like. Subscriber unit 26 monitors a signaling channel transmitted by access point 22 for each coverage area 24. Subscriber unit 26 only consumes bandwidth when instructed to transmit by the signaling channel or when receiving packets.

10 Each access point 22 communicates with at least one distribution point

40. Distribution point 40 contains both routing and switching functionality. Access point 22 may be in contact with one or more radio access distribution points 40 over radio link 42, may be wired or cabled to distribution point 40 through wireline link 44, or may be packaged with distribution point 40. Access point 22 may also be
15 transformed into distribution point 40, permitting access point 22 to route traffic that,
neither originated nor terminated with any of its serviced subscriber units 26,
Distribution point 40 is in communication with at least one additional distribution
point 40, the collection of interconnected distribution points forming a network of
distribution points, shown generally by 41. Two distribution points may be
20 connected by radio link 46 or wireline link 48.

Distribution points 40 may route packets within distribution point network 41 under a variety of protocols such as ATM, TCP/IP, 802.x, or the like. In a preferred embodiment, distribution point 40 includes an ATM/IP switch. Distribution point 40 then operates at both the IP routing and ATM switching layers
25 or, in terms of the Open Systems Interconnection (OSI) standard, at both the network layer and the data link layer.

The IP layer operates with a link-state protocol such as the open shortest path first (OSPF), quality OSPF (Q-OSPF), or internal gateway routing protocol (IGRP) and its derivatives. The IP layer operates as a single autonomous system (AS) within the IP frame of reference. Each system 20 will be allocated a
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unique and unambiguous AS number for system management. IP addresses for system 20 will use a private IP address space that cannot be routed within public systems such as the Internet. Subscriber units 26 within system 20 may be permitted access to the private IP address space or may be excluded from the private IP address space. When private IP address space is used for subscriber units 26, a network address translator (NAT) within system 20 allows subscriber units 26 access to the Internet. The ATM layer operates with the private network node interface (PNNI) routing protocol. ATM end system addresses (AESAs), managed by the service provider for system 20, are used by distribution point network 41.

10 The ATM network carries voice traffic and may carry data. Through PNNI, the ATM/IP switch participates in switched or signaled virtual connections (SVCs). When subscriber unit 26 within system 20 requires voice connectivity, it signals such a request, which is serviced by distribution point 40 receiving that request. The IP network coresiding with the ATM network is used for delay insensitive data applications required by subscriber units 26. The IP network is also used for all network management, including management of ATM/IP switches, subscriber units 26, gear associated with distribution points 40, and any other suitable network component. This includes functions such as alarming, monitoring, recovery systems, and the like. While described in the context of a wireless network application, it is readily apparent that ATM/IP routing as described herein may be applied to wireline and mixed wireline-wireless systems as well.

25 Each distribution point 40 receives an information packet from either another distribution point 40, from subscriber unit 26 in communication with distribution point 40 through access point 22, or from an external communication system. If distribution point 40 determines the information packet is destined for subscriber unit 26 within coverage area 24 of access point 22 in communication with distribution point 40, distribution point 40 forwards the packet to access point 22 forming coverage area 24 containing destination subscriber unit 26. If distribution point 40 determines the information packet is destined for subscriber unit 26 in 30 coverage area 24 formed by access point 22 in communication with a different distribution point 40, distribution point 40 forwards the packet to one of distribution

points 40 in communication with distribution point 40. Hence, no central MSC is required for routing. Distributed routing removes delays caused by central switching, increases the robustness of the communication system 20, increases network efficiency, and permits simplified expansion or reduction of communication system 20 by automatically adding or removing distribution points 40.

A third option is that distribution point 40 determines that the information packet is destined for a destination not part of communication system 20. Special distribution points, such as gateway 50, provide a bridge to additional communication systems 52 including wireless and wireline telecommunication systems, video distribution systems, computer network systems such as the Internet, packet systems, frame systems, ATM systems, IP systems, private networks, and any other suitable communication or information system. If distribution point 40 determines the information packet is destined for delivery outside of communication system 20, distribution point 40 forwards the packet to one of distribution points 40 in communication with gateway 50.

In an embodiment of the present invention, communication system 20 includes communication system interface device 54 operative to format information contained in the information packet to pass through telecommunication system 52. Communication system interface device 54 may be incorporated into gateway 50 or may be a separate component of communication system 20. Distribution point 40 receives at least one information packet from the telecommunication system interface device 54 and determines if the at least one information packet destination is to subscriber unit 26 within coverage area 24 of access point 22 in communication with distribution point 40. Distribution point 40 forwards the at least one information packet to access point 22 defining coverage area 24 containing subscriber unit 26 if the information packet destination is to subscriber unit 26 within coverage area 24 of access point 22 in communication with distribution point 40 and forwards the at least one information packet to one of the additional distribution points 40 in communication with distribution point 40 otherwise.

Each distribution point 40 communicates with supervisor 56. Supervisor 56 tracks the locations of subscriber units 26 within communication system 20, identifying with which distribution point 40 each subscriber unit 26 is currently communicating. Supervisor 56 manages transmission priorities based on 5 parameters including load, information type, service requests, location, grade of service, information transfer rates, or any other suitable parameter. Supervisor 56 may also serve as a collection point for alarms and performance measuring of communication system 20. Supervisor 56 may further include or interface with billing and authentication services.

10 In an embodiment of the present invention, supervisor 56 also assigns an address to each distribution point 40 as distribution point 40 is added to communication system 20. Supervisor 56 provides each distribution point 40 with a logical address and a listing indicating to which additional distribution point 40 in communication with distribution point 40 information packets should be forwarded 15 for each possible destination distribution point 40. The listing may be based on maintaining a minimum quality of service in the path through distribution point network 41 to the destination distribution point 40. Supervisor 56 periodically assesses the performance of network 41 by sending test messages. Reports may also be generated by distribution points 40 attempting to communicate with target 20 addresses.

Supervisor 56 is shown in Figure 1 as a separate component individually connected to each distribution point 40. Alternatively, communication between supervisor 56 and distribution points 40 may be through radio links 46 and wireline links 48. Supervisor 56 may be one or more separate components of 25 communication system 20, may be incorporated into one of distribution points 40, or may be distributed amongst multiple distribution points 40.

30 In an embodiment of the present invention, a distribution point may be automatically added to or removed from distribution point network 41. When new distribution point 40 is first inserted into communication system 20, new distribution point 40 transmits a signature signal. Existing distribution points 40

within range of new distribution point 40 receive the signal and report it to supervisor 56. Supervisor 56 then determines if new distribution point 40 will be added to network 41. If so, supervisor 56 assigns new distribution point 40 a routing address and informs network 41 as needed. Each existing distribution point 5 40 in distribution point network 41 is provided with an indication as to which distribution point 40 in communication with existing distribution point 40 each information packet having a destination address specifying the new distribution point 40 is to be forwarded. If a distribution point 40 is removed from network 41, remaining distribution points 41 report the absence of removed distribution point 40 10 to supervisor 56. Supervisor 56 then informs network 41 as needed.

In an embodiment of the present invention, each subscriber unit 26 is autonomously registered with communication system 20 when subscriber unit 26 first enters coverage area 24 within communication system 20. Each subscriber unit 26 maintains registration as subscriber unit 26 moves from one coverage area 24 into 15 another coverage area 24 within communication system 20 and is autonomously deregistered when subscriber unit 26 leaves communication system 20. To accomplish automatic registration and deregistration of subscriber units 26, each access point 22 periodically reports the status of subscriber units 26 within any controlled coverage area 24 to supervisor 56 performing registration and authentication. Each access point 22 communicates with subscriber units 26 to 20 determine status. When a subscriber unit 26 voluntarily enters or leaves coverage area 24, such as by powering up or down, subscriber unit 26 transmits a particular signal to access point 22. Information is also received from subscriber unit 26 in response to periodic queries from network 20. Access point 22 may determine the 25 absence of subscriber unit 26 from coverage area 24 if no communication is received after a particular time interval. Algorithms for registering and deregistering subscriber units 26 may be based on various factors including quality of service, traffic, location, service type, network topology, and the like.

Referring now to Figure 2, a block diagram of a distribution point 30 according to an embodiment of the present invention is shown. Distribution point 40 includes one or more front end communication interfaces 100, each front end

interface communicating with one access point 22. In one configuration, access point 22 is packaged with distribution point 40. Front end interface 100 may provide a plug-in port for receiving access point 22. In another configuration, front end interface 100 connects to antenna 102 for establishing radio link 42 with access point 22. In a further configuration, front end interface 100 accepts wireline link 44 connecting distribution point 40 with access point 22. Front end interface 100 operates using a standard packet switching protocol such as, for example, ATM25. Each front end communication interface 100 passes information packets through common front end switch interface 104 operating under a packet protocol such as 5 ATM, TCP/IP, 802.x, or the like.

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Distribution point 40 also includes back end communication interfaces 106 for connecting distribution point 40 with additional distribution points 40, with supervisor 56, and, if distribution point 40 is a gateway 50, with telecommunication systems, private network systems, video distribution systems, the Internet, or the like. This may be typically referred to as back haul communication. In one configuration of the present invention, back end interface 106 connects to antenna 108 for establishing radio link 46 with another distribution point 40. In another configuration, back end interface 104 accepts wireline link 44 connecting distribution point 40 with another distribution point 40. In a preferred embodiment, back end interface 106 accepts modules 110 for interfacing through a variety of protocols and media such as ATM25, DS1, DS3, OC3, 1000Base-T, 100Base-T, and the like. Each back end communication interface 106 passes information packets through common back end switch interface 112 operating under a packet protocol such as ATM, TCP/IP, or the like. In a preferred embodiment, distribution point 40 15 dynamically allocates bandwidth when the information packet is forwarded to one of the additional distribution points 40 in communication with distribution point 40.

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Intelligent packet switch 114 received information packets through common front end switch interface 104 and common back end switch interface 112 and routes the packets between front end interfaces 100 and back end communication 30 interfaces 106. Switch 114 may be a packet switching device as is known in the art such as an ATM switch, an IP switch, a TDM switch, a switch working under the

802.11 specification, or any other suitable alternative or combination having the required switching functionality. In an embodiment of the present invention, switch 114 includes an ATM portion for routing voice, video and data, and an IP portion for real-time dynamic data routing and non-real time data routing as well as 5 administration, management, and network topology control.

In an embodiment of the present invention, distribution point 40 is enclosed in an environmentally sealed package. This permits distribution point 40 to be mounted outside, such as on a pole or the side of a building. In keeping with the invention, however, distribution point 40 need not be outside so long as it can 10 communicate with access points 22, additional distribution points 40, supervisor 56, and any other suitable network component.

Referring now to Figure 3, a schematic drawing illustrating an implementation of a communication system according to an embodiment of the present invention is shown. This implementation provides an example including 15 interfaces between communication system 20 and a variety of external communication systems 52.

Communication system 20 includes wireless service location registers (WSLRs) 200 providing common subscriber and service databases. Each WSLR 200 communicates with at least one distribution point 40 and one additional 20 communication system 52. Connections between WSLRs 200 and communication systems 52 are not shown in Figure 3 for clarity. Each WSLR 200 provisions requested services from additional communication system 52. For example, WSLR 200 may provide centralized mobility and location management. Supervisor 56 determines which WSLR 200 will provision services based on the distribution point 25 40 through which subscriber unit 26 requesting services is currently communicating. A device that may serve as WSLR 200 is described in U.S. Patent No. 5,974,331 titled "Method And System For Dynamically Assigning Features And Users To Wireline Interfaces," to Cook *et al.* Call agents may also function as WSLR-like devices to map or integrate additional communication systems with system 20.

Communication system 20 may also include multi-service platform (MSP) 202. MSP 202 provides access to wireline telephone systems (PSTN). This may be accomplished through GR-303 compliant connection 204. Signaling point of interface (SPOI) 206 serves as the demarcation point between communication system 20 and external communication system 52. In the example shown, GR-303 connection 204 connects wireline provider 208, serving wired customers 210, with communication system 20. MSP 202 may integrate both PSTN and IP networks as well as provide enhanced circuit/packet switch services.

At least one gateway 212 supports MSP 202. Communication system 10 20 may include, for example, voice-over-ATM (VoATM) to GR-303 gateways and voice over IP (VoIP) to GR-303 gateways. Gateway 212 serves as a protocol agent, converting information packets to a format acceptable to additional communication system 52. A determination as to which gateway 212 will process an information packet may be based on information contained within the information packet. 15 Gateways 212 may be connected to MSP 202 by GR-303 compliant connection 214.

Communication system 20 may also include gateway 216 connecting communication system 20 with external data network 52 such as the Internet or a private data network interconnecting network users 218. Gateway 216 may, for example, convert between various packet-based standards such as H.323 and SIP.

20 Communication system 20 may also include gateway 220 interfacing communication system 20 with external SS7 network 52 represented by signal transfer point (STP) 222. Gateway 220 communicates with STP 222 through ISUP compliant connection 224 which permits setting up and taking down trunk calls, calling party information services, call status, and any other suitable network 25 function, by passing signaling information through SS7 network 52 to wireline provider 208 under the control of integrated services control point (ISCP) 226.

Communication system 20 may also include unified message center (UMC) 228. Unified messages, also known as integrated messages, permit messages from a variety of sources such as telephone, email, fax, reports, compound

documents, or any other suitable information or communication device, to be summarized and presented on a single medium, such as a personal computer. Messages may even be translated from one media type to another. UMC 228 supports unified message applications within communication system 20. In an 5 embodiment, UMC 228 communicates with wireline provider 208, permitting greater integration, flexibility and access to messages.

Connection controller 230 controls access to gateways 50, 202, 212, 216, 220, or any other suitable interface. For example, connection controller 230 may manage voice over ATM to GR-303 access, voice over IP to GR-303 access, 10 H.323/SIP to Internet remote access, SS7 to IP access, and the like. Connection controller 230 may also support information rate adaptation including open application processor interfaces and robust application development platforms.

Referring now to Figures 4-6, drawings illustrating dynamic growth of a distribution point network according to an embodiment of the present invention 15 are shown. An initial configuration for system 20 is shown in Figure 4. ATM/IP switch 300 is in communication with supervisor 56 through ATM virtual connection 302. In this simple configuration, ATM/IP switch 300 may be functioning as access point 22. ATM/IP switch 300 may obtain an IP address and an ATM address either manually or automatically.

20 ATM/IP switch 300 automatically requests addresses by first broadcasting an ATM request in an IP packet over virtual connection (VC) 302. Supervisor 56 forwards this request to address server 304. Address server 304 responds by allocating unique ATM end system address (AES) 306 to the address assignment client in ATM/IP switch 300, which updates the ATM layer with new 25 address 306. The address assignment client in ATM/IP switch 300 next requests from address server 304 an IP address, again using IP as the transport service over pre-existing ATM VC 302. Address server 304 forwards IP address 308 to ATM/IP switch 300. ATM/IP switch 300 then requests address pools for ATM and IP. Address server 304 responds by supplying AESA pool 310 and IP address pool 312.

Pools of addresses 310, 312 are used by switch 300 when functioning as distribution point 40 in support of other distribution points 40 and access points 22.

Referring now to Figure 5, a drawing illustrating the addition of a second access point is shown. Access point 22 has the capability to function as a distribution point 40. As new access points 22 are subtended from an existing access point 22, existing access point 22 becomes a distribution point 40. Each distribution point 40 continues to communicate with its initially connected distribution point 40 and with other distribution points 40 as they are provisioned. As new links 46, 48 between distribution points are created, distribution points 40 form peer relationships at both the ATM layer and the IP layer. Distribution points 40 are always peers at the IP and ATM layer, while access points 22 are clients of distribution points 40. As such, each ATM/IP switch 300 functions as a server when operating as distribution point 40 and as a client when operating as access point 22.

When new ATM/IP switch 320 is instantiated as access point 22, it will automatically request an ATM address in an IP packet address assignment request. This IP packet will be sent in an ATM frame over radio link 46 to IP/ATM switch 300 functioning as distribution point 40 using a pre-existing ATM VC. IP/ATM switch 300 will allocate unique ATM address 322 from AESA pool 310 and unique IP address 324 from IP address pool 312. ATM/IP switch 320 then sends a directed request to address server 304 and receives its own AESA pool 326 and IP address pool 328.

Referring now to Figure 6, a hierarchical routing network is shown. Address server 304 assigns AESA pool 310 and IP address pool 312 as each ATM/IP switch 300 is added. By handling all requests for address pools 310, 312, address server 304 maintains a hierarchy of addresses for both ATM and IP layers. Address server 304 constructs routing tables for each ATM/IP switch 300 indicating to which directly connected ATM/IP switch 300 each incoming packet should be routed if the packet is not destined to subscriber unit 26 serviced by that ATM/IP switch 300. Thus, routing tables are cohesive, reflecting the view of communication system 20 seen by each ATM/IP switch 300. Address server 304 also constructs

forward equivalency class (FEC) tables permitting ATM/IP switch 300 to route packages based on package contents. FECs can be seen as either the virtual path identifier (VPI) portion of the ATM VPI/VCI or as the entire VPI/VCI, and are enabled by the routing protocols at the IP and PNNI layers.

5 New routing elements are dynamically added to a network of routing elements by establishing a connection between the new routing element and an existing routing element in the network of routing elements. At least one address is assigned to the new routing element, each assigned address coming from a pool of addresses maintained at the existing routing element. At least one pool of addresses 10 is issued to the new routing element. The one or more pool of addresses permitting the new routing element to dynamically add yet another new routing element to the network of routing elements.

15 In an embodiment of the present invention, a method of dynamically adding a routing element to a distributed communications includes establishing an ATM virtual connection with an existing distribution point already part of the communications network. An ATM end user address is requested from the existing distribution point. An ATM end user address is obtained from the existing distribution point, the ATM end user address allocated from a pool of ATM end user addresses in the existing distribution point. An IP address is requested from the 20 existing distribution point. An IP address is obtained from the existing distribution point, the IP address allocated from a pool of IP addresses in the existing distribution point. Preferably, a pool of ATM end user addresses is requested and received from an address server. A pool of IP addresses is requested and received from the address server. An ATM end user address from the pool of ATM end user addresses and 25 an IP address from the pool of IP addresses may be assigned to a new routing element requesting to be added to the communications network.

30 In an embodiment of the present invention, when a new distribution point is added to a network of distribution points, a connection is established between the new distribution point and at least one existing distribution point in the network of distribution points. A peer-to-peer relationship is formed at the OSI

network layer between the new distribution point and the at least one existing distribution point. A peer-to-peer relationship is formed at the OSI data link layer between the new distribution point and the at least one existing distribution point.

5 In an embodiment of the present invention, when an access point is added to a network of distribution points, a connection is established between the access point and at least one existing distribution point in the network of distribution points. A client-server relationship is formed at the OSI network layer between the access point client and the at least one existing distribution point server. A client-server relationship is formed at the OSI data link layer between the access point and
10 the at least one existing distribution point server.

15 In an embodiment of the present invention, when an ATM/IP switch 300 is removed from communication system 20, all of the addresses 306, 308 and address pools 310, 312 associated with the removed switch 300 are released. Addresses 306, 308 and address pools 310, 312 may be instantiated at distribution point 40 which originally supplied removed switch 300 with addresses 306, 308, may be sent to supervisor 56, or may be split with addresses 306, 308 returning to distribution point 40 and address pools 310, 312 returning to supervisor 56.

20 When subscriber unit 26 first enters communication system 20, it is detected and serviced by access point 22. Subscriber unit 26 is provided with one or more addresses, each address routable within at least the local hierarchy of ATM/IP switches 300. If subscriber unit 26 enters the range of a new access point 22, new access point 22 sends out a flooding FEC routing update for the ATM address of subscriber unit 26. Previously servicing access point 22 removes subscriber unit 26 from its own FEC upon receiving the FEC update. Any 25 subsequent ATM packets received by previously servicing access point 22 are discarded.

When subscriber unit 26 changes access points 22, the IP routing portion of system 20 moves the IP address of subscriber unit 26 from one FEC class to another. Any IP packets remain untouched, with only a label or equivalence

changed. In one embodiment, the label is the VPI portion of the VC. In another embodiment, multiprotocol label switching (MPLS) is used to provide an additional label. In either case, the IP address and virtual connection identifier (VCI) are retained.

5 Referring now to Figure 7, a schematic drawing illustrating a network of distribution points routing packets based on forwarding equivalency classes is shown. Each distribution point contains an FEC table 400 used to route packets received from and destined to subscriber units 26. Forwarding equivalency class table 400 contains one entry for each forwarding equivalency class 402. In the 10 embodiment shown, there is one FEC 402 corresponding to each access point 22. When subscriber unit 26 is first detected by access point 22, the address for subscriber unit 22 is placed in the equivalency class 402 corresponding to the detecting access point 22. The address is typically an IP address. This may be done by broadcasting from detecting access point 22 or, preferably, is done by supervisor 15 56 after supervisor 56 receives a message indicating subscriber unit 26 has been detected by access point 22.

FEC table 400 in each distribution point 40 contains the next destination for each FEC 402. Typically, destinations are other distribution points 40, access points 22 serviced by distribution point 40, gateways 50, and other 20 suitable points for routing, switching, servicing, distributing, and the like. When a packet destined for subscriber unit 26 is received by distribution point 40, distribution point 40 determines to which FEC subscriber unit 26 is assigned, determines to which destination the packets in that FEC are routed, and forwards the packet to the determined destination.

25 Referring now to Figure 8, a schematic drawing illustrating forwarding equivalency class updating to track a moving subscriber unit is shown. If subscriber unit 26 is mobile or portable, as indicated by U1 in Figure 8, subscriber unit 26 may move out of coverage area 24 for one access point 22 and into coverage area 24 for a new access point 22. The address for subscriber unit 26 30 is then moved from FEC 402 of original access point 22 into FEC 402 for new

access point 22. In an embodiment, when original access point 22 is no longer in communication with subscriber unit 26, original access point 22 broadcasts a message to distribution points 40 and supervisor 56. If original access point 22 subsequently receives any packets for subscriber unit 26, original access point 5 forwards these packets back into distribution point network 41. If the packets are sequentially indicated, such as IP packets, correct order will be established by subscriber unit 26 when packets are received.

Referring now to Figure 9, a schematic drawing illustrating high-speed information services through distributed routing and hybrid local loops according to an embodiment of the present invention is shown. Distribution point 10 40 that services access points 22 includes at least one host digital terminal (HDT) 500. Each HDT 500 converts a VDSL or other high-speed information packet to an optical format if that packet is destined for subscriber 502 connected through HDT 500. The VDSL packet is then forwarded to the appropriate optical network unit (ONU) 504 through fiber 506. The ONU converts the packet from an optical format into a format compatible with copper cabling 508, such as UTP, and routes the packet to a network interface device (NID) 510 at the subscriber premises. Alternatively, HDT 500 may be directly connected to NID 510 by optical fiber 506. Hence, either HDT 500 or ONU 504 may function as an access point 22.

20 NID 510 receives the DSL packets and forwards the packets to customer premises equipment (CPE) 512, such as a gateway or modem. Preferably, the CPE serves as an interface for various customer communication and information devices including computers, audio and video receivers, telephones, video phones, telemetry equipment, and the like. The use of HDT 500 to carry multiple channels 25 of information to CPE 512 is described in U.S. Patent Application Serial No. 09/339,597 titled "System and Method for Providing Broadband Data Service" to Bruce Phillips *et al.*, filed June 24, 1999.

30 As described above, information packets may come from a variety of sources. Information packets may transfer between subscriber units 26 within communication system 20 or between subscriber unit 26 within communication

system 20 and a communication device outside of communication system 20. External communication systems interfacing with communication system 20 include service and data providers such as telecommunication system 514, video content supplier 515, data supplier 516, Internet service provider (ISP) 517, data networks 5 such as Internet 518, and the like.

For switched video, HDT 500 or ONU 504 may also function as a video distribution center (VDC). In one embodiment, the VDC receives requests from customer gateways or subscriber units 26 and relays these requests to one or more video suppliers 515. If multiple receivers are viewing the same channel, the 10 VDC does not duplicate the request, but rather forwards the video content to each appropriate premises 502.

Referring now to Figure 10, a schematic drawing illustrating high-speed information services through distributed routing and non-hybrid local loops according to an embodiment of the present invention is shown. In this embodiment, 15 the need for fiber-to-the-neighborhood (FTTN) is eliminated. Each NID 510 connects via DSL cabling 520 to an access point 22. Access point 22 may communicate through a distribution point by wireless connection 42, may communicate through a wire line connection 44, or may be incorporated into the distribution point 40. For switched video applications, either distribution point 40 20 or access point 22 may function as a VDC.

Referring now to Figure 11, a schematic drawing illustrating high-speed information services through distributed routing and wireless customer delivery according to an embodiment of the present invention is shown. In some or all connections, subscriber units 26 may connect to access point 22 using high-speed 25 wireless communication links 28. Within customer premises, NID 510 and CPE 512 are replaced by terminal network controller 30. For switched video applications, either distribution point 40 or access point 22 may function as a VDC.

In Figures 12 and 13, flow diagrams illustrating operation of a distribution channel are provided. As will be appreciated by one of ordinary skill

in the art, the operations illustrated in the flow diagrams are not necessarily sequential operations. The order of steps may be modified within the spirit and scope of the present invention. Also, the methods illustrated in Figures 12 and 13 may be implemented by any combination of hardware, software, firmware, and the like. The present invention transcends any particular implementation and the embodiment is shown in sequential flow chart form for ease of illustration. Further, while the particular implementation of a video channel is described, it will be recognized that the present invention is applicable to any type of broadcast information, including audio, emergency response information, data distribution, conferencing, safety and security information, advertisements, public service announcements, gaming, and the like.

Referring now to Figure 12, a flow diagram illustrating reception of a request for a video channel by a distribution center according to an embodiment of the present invention is shown. A VDC receives a request from subscriber unit 26 to access a video channel in block 600. This request may be received as a message generated by user selection, such as by changing the channel on an entertainment receiver, or by having subscriber unit 26 enter coverage area 24 controlled by a routing element functioning as the VDC such as access point 22 or distribution point 40.

A check is made to determine if another subscriber unit 26 served by the VDC is receiving the requested video channel in block 602. If not, the VDC requests that information packets for the video channel be transmitted to the VDC in block 604. In an embodiment, the VDC gives a dummy address as the destination for the requested video channel information packets. This dummy address may be the IP or ATM address of the VDC, or may be the address of a fictitious subscriber unit 26 assigned to the VDC. The dummy address permits various subscriber units 26 to request and terminate a video channel from the VDC without disturbing any distribution to other subscriber units 26 that may be receiving the same video channel through the VDC.

A notation is made that the requesting subscriber unit 26 is receiving the video channel in block 606. This may be done by keeping a simple table of subscriber units 26 and received video channels, by entries into a database, by creation of objects holding the subscriber unit 26 and video channel information, or 5 by any other method of mapping subscriber units 26 and video channels. This notation is preferably kept by the VDC but may also be kept by the video channel provider, supervisor 56, or any other suitable component. The notation is used to replicate or broadcast each video packet to all subscriber units 26 requesting the video channel containing the video packet.

10 Referring now to Figure 13, a flow diagram illustrating termination of a request for a video channel by a distribution center according to an embodiment of the present invention is shown. A VDC determines that subscriber unit 26 is no longer accessing a particular video channel in block 610. This determination may be based on receiving a message from subscriber unit 26 that the video channel is 15 no longer needed or may be based on determining that subscriber unit 26 is no longer in coverage area 24 served by the VDC.

20 A check is made in block 612 to determine if any other subscriber unit 26 is receiving the video channel. If no other subscriber unit 26 is receiving the video channel, channel transmission is canceled in block 614. A notation is made that subscriber unit 26 is no longer receiving the video channel in block 616.

25 While embodiments of the invention have been illustrated and described, it is not intended that these embodiments illustrate and describe all possible forms of the invention. Rather, the words used in the specification are words of description rather than limitation, and it is understood that various changes may be made without departing from the spirit and scope of the invention.

WHAT IS CLAIMED IS:

- 1 1. A communication system comprising:
2 a plurality of subscriber units, each subscriber unit sending and
3 receiving information packets using a wireless communication link;
4 a plurality of access points, each access point forming a coverage area
5 for exchanging information packets with subscriber units within the coverage area;
6 and
7 a plurality of distribution points, each distribution point in
8 communication with at least one access point and with at least one additional
9 distribution point, each distribution point operative to
 - 10 (a) receive an information packet for distribution to a destination
11 within the communication system,
 - 12 (b) determine if the information packet destination is to a
13 subscriber unit within the coverage area of an access point in
14 communication with the distribution point,
 - 15 (c) forward the information packet to the access point defining
16 the coverage area containing the subscriber unit if the
17 information packet destination is to a subscriber unit within
18 the coverage area of the access point in communication with
19 the distribution point, and
 - 20 (d) forward the information packet to one of the additional
21 distribution points in communication with the distribution
22 point if the information packet destination is not to a
23 subscriber unit within the coverage area of the access point in
24 communication with the distribution point.
- 1 2. A communication system as in claim 1 wherein each
2 information packet includes at least one of voice, video, and data information.
- 1 3. A communication system as in claim 1 wherein an information
2 packet comprises voice information.

1 4. A communication system as in claim 1 wherein an information
2 packet comprises video information.

1 5. A communication system as in claim 1 wherein an information
2 packet comprises data.

1 6. A communication system as in claim 1 wherein an information
2 packet comprises streaming audio.

1 7. A communication system as in claim 1 wherein an information
2 packet comprises streaming video.

1 8. A communication system as in claim 1 wherein the
2 communication link is a symmetric link.

1 9. A communication system as in claim 1 wherein the
2 communication link is an asymmetric link.

1 10. A communication system as in claim 1 wherein each
2 distribution point is in wireless communication with at least one access point.

1 11. A communication system as in claim 1 wherein at least one
2 distribution point is in wireline communication with at least one access point.

1 12. A communication system as in claim 1 wherein at least one
2 access point is packaged with a distribution point.

1 13. A communication system as in claim 1 wherein at least one
2 access point is not collocated with any distribution point.

1 14. A communication system as in claim 1 wherein at least one
2 distribution point is in wireless communication with at least one additional
3 distribution point.

1 15. A communication system as in claim 1 wherein the plurality
2 of distribution points forms a wireless network of distribution points.

1 16. A communication system as in claim 1 further comprising a
2 communication system interface device operative to format information contained in
3 the information packet to pass through a second communication system, the
4 distribution point further operative to receive an information packet for distribution
5 within the second communication system and to send the information packet to the
6 second communication system interface device.

1 17. A communication system as in claim 16 wherein the second
2 communication system comprises a wireless telecommunication system.

1 18. A communication system as in claim 16 wherein the second
2 communication system comprises a wireline telecommunication system.

1 19. A communication system as in claim 16 wherein the second
2 communication system comprises a data network.

1 20. A communication system as in claim 16 wherein the second
2 communication system comprises a video distribution system.

1 21. A communication system as in claim 1 further comprising a
2 telecommunication system interface device operative to format information contained
3 in the information packet to pass through a telecommunication system, the
4 distribution point further operative to:

5 receive at least one information packet from the telecommunication
6 system interface device;

7 determine if the at least one information packet destination is to a
8 subscriber unit within the coverage area of an access point in communication with
9 the distribution point;

10 forward the at least one information packet to the access point
11 defining the coverage area containing the subscriber unit if the information packet
12 destination is to a subscriber unit within the coverage area of the access point in
13 communication with the distribution point; and

14 forward the at least one information packet to one of the additional
15 distribution points in communication with the distribution point if the information
16 packet destination is not to a subscriber unit within the coverage area of the access
17 point in communication with the distribution point.

1 22. A communication system as in claim 1 wherein at least one
2 distribution point is further in communication with an Internet gateway, the
3 distribution point further operative to exchange packets with the Internet gateway.

1 23. A communication system as in claim 1 wherein at least one
2 distribution point comprises an asynchronous transfer mode switch.

1 24. A communication system as in claim 1 wherein at least one
2 distribution point comprises an Internet protocol router.

1 25. A communication system as in claim 1 wherein at least one
2 distribution point comprises an Ethernet router.

1 26. A communication system as in claim 1 wherein at least one
2 distribution point comprises a TDM switch.

1 27. A communication system as in claim 1 wherein each subscriber
2 unit is autonomously registered when the subscriber unit first enters the coverage
3 area of a radio access point within the communication system.

1 28. A communication system as in claim 27 wherein each
2 subscriber unit maintains registration as the subscriber unit moves from one coverage
3 area into another coverage area.

1 29. A communication system as in claim 27 wherein each
2 subscriber unit is autonomously deregistered when the subscriber unit leaves the
3 communication system.

1 30. A communication system as in claim 1 wherein a quality error
2 bit rate is established for each subscriber unit based on the location of the subscriber
3 unit within the communication system.

1 31. A communication system as in claim 1 wherein a quality error
2 bit rate is established for each subscriber unit based on a class of service.

1 32. A communication system as in claim 1 wherein a quality error
2 bit rate is established for each subscriber unit based on a grade of service.

1 33. A communication system as in claim 1 wherein a quality error
2 bit rate is established for each subscriber unit based on a rate of service.

1 34. A communication system as in claim 1 wherein the subscriber
2 unit is a fixed device.

1 35. A communication system as in claim 1 wherein the subscriber
2 unit is a non-fixed device.

1 36. A communication system as in claim 1 wherein the distribution
2 point dynamically allocates bandwidth when the information packet is forwarded to
3 one of the additional distribution points in communication with the distribution point.

1 37. A communication system as in claim 1 wherein bandwidth is
2 dynamically allocated when an information packet is exchanged between one of the
3 plurality of subscriber units and one of the plurality of access points.

1 38. A communication system as in claim 1 wherein each subscriber
2 unit sends and receives information as a plurality of packets over a communication

3 link, each subscriber unit operative to surrender communication link bandwidth when
4 not sending or receiving an information packet.

1 39. A communication system as in claim 1 wherein each subscriber
2 unit sends and receives information as a plurality of packets transmitted over a
3 communication link, communication link bandwidth consumed only when packets
4 containing information are transmitted, thereby only utilizing link bandwidth when
5 information is sent or received.

1 40. A communication system as in claim 1 further comprising a
2 supervisor in communication with each distribution point, the supervisor operative
3 to identify the distribution point with which each subscriber unit is communicating.

1 41. A communication system as in claim 1 further comprising a
2 supervisor in communication with each distribution point, the supervisor operative
3 to provide each distribution point with a listing of to which of the at least one
4 additional distribution point in communication with the distribution point information
5 packets should be forwarded for each possible destination distribution point, the
6 listing based on maintaining a minimum quality of service in the path to the
7 destination distribution point.

1 42. A communication system as in claim 1 wherein at least one of
2 the plurality of distribution points comprises at least one host digital terminal (HDT)
3 for converting information packets to an optical format and forwarding the
4 information packets to subscriber units.

1 43. A communication system as in claim 42 wherein at least one
2 subscriber unit is operative to receive information packets in an optical format.

1 44. A communication system as in claim 42 further comprising at
2 least one access point in communication with the at least one HDT, the access point
3 operative to convert information packets in an optical format into a format
4 compatible with copper cabling.

1 45. A communication system as in claim 44 wherein at least one
2 subscriber unit is in communication with the at least one access point through a
3 network interface device.

1 46. A communication system as in claim 42 wherein packetized
2 information is provided through a VDSL service.

1 47. A communication system as in claim 1 further comprising at
2 least one distribution center.

1 48. A communication system as in claim 47 wherein at least one
2 access point functions as a distribution center.

1 49. A communication system as in claim 47 wherein at least one
2 of distribution point functions as a distribution center.

1 50. A communication system as in claim 47 wherein at least one
2 distribution center is operative to receive requests for information content from at
3 least one subscriber unit and forward those requests to at least one information
4 supplier.

1 51. A communication system as in claim 47 wherein at least one
2 distribution center forwards information packets comprising a channel to each
3 subscriber unit served by the distribution center and requesting the channel.

1 53. A communication system as in claim 47 wherein the at least
2 one distribution center replicates information packets comprising an information
3 channel for each of a plurality of subscriber units requesting the information channel.

1 54. A communication system as in claim 47 wherein at least one
2 distribution center is operative to

3 receive a request to access an information channel from a subscriber
4 unit;

5 determine if the requested information channel is currently being
6 accessed by another subscriber unit served by the access point; and

7 if the requested information channel is not currently being accessed
8 by another subscriber unit served by the access point, forwarding the request to an
9 information supplier.

1 55. A communication system as in claim 47 wherein at least one
2 distribution center forwards information packets to each subscriber unit requesting
3 the information channel associated with each information packet, the at least one
4 distribution center receiving a request from a subscriber unit based on a
5 determination that the requesting subscriber unit is within the coverage area of the
6 at least one distribution center.

1 56. A communication system as in claim 47 wherein at least one
2 distribution center forwards information packets to each subscriber unit requesting
3 the information channel associated with each information packet, the at least one
4 distribution center receiving a request from a subscriber unit based on a message
5 from a subscriber unit.

1 57. A communication system as in claim 47 wherein at least one
2 distribution center transmits a dummy address as the destination for a requested
3 transmission of an information channel.

1 58. A communication system as in claim 47 wherein at least one
2 distribution center notes that the requesting subscriber unit is receiving the requested
3 information channel.

1 59. A communication system as in claim 47 wherein at least one
2 distribution center determines that a subscriber unit is no longer accessing an
3 information channel and cancels transmission of the information channel if no other
4 subscriber unit is receiving the information channel.

1 60. A method for routing packets in a packetized communication
2 system including a plurality of subscriber units comprising:
3 establishing a distributed network of distribution points;
4 breaking information into a plurality of packets at a transmitting
5 subscriber unit, each subscriber unit in communication with at least one distribution
6 point in the network of distribution points;
7 transmitting the plurality of packets to a distribution point in
8 communication with the transmitting subscriber unit;
9 providing each packet of the plurality of packets with an address, the
10 address indicating a destination distribution point within the communication system;
11 in each distribution point along a path of distribution points to the
12 destination distribution point, determining to which distribution point each packet
13 will be forwarded based on the address;
14 receiving each packet in the destination distribution point;
15 forwarding each packet to a destination subscriber unit if the
16 destination is a subscriber unit in communication with the destination distribution
17 point; and
18 assembling the information from the plurality of packets at the
19 destination subscriber unit.

1 61. A method for routing packets as in claim 60 further
2 comprising:
3 determining that the destination is to a receiver outside of the
4 communication network;
5 providing each packet with an address specifying a destination
6 distribution point functioning as a gateway to a communication system supporting
7 the receiver if the destination is determined to be to a receiver outside of the
8 communication network; and
9 forwarding each packet from the gateway distribution point to the
10 communication system supporting the receiver.

1 62. A method for routing packets as in claim 60 wherein
2 bandwidth is shared between a plurality of subscriber units, the method further
3 comprising:

4 selecting one of the plurality of subscriber units for transmitting;
5 broadcasting an identification of the selected subscriber unit over a
6 signaling channel;

7 determining within the selected subscriber unit any packets that are
8 to be transmitted;

9 transmitting the determined packets over an information channel; and
10 queuing packets within nonselected subscriber units for later
11 transmission.

1 63. A method for routing packets as in claim 60 further
2 comprising:

3 transmitting a sign-on signal from a new distribution point not yet part
4 of the distributed network of distribution points;

5 receiving the sign-on signal by at least one existing distribution point
6 in the distributed network of distribution points;

7 assigning a routing address to the new distribution point; and

8 providing each existing distribution point with an indication as to
9 which additional distribution point in communication with the existing distribution
10 point each information packet having a destination address specifying the new
11 distribution point is to be forwarded.

1 64. A method for routing packets as in claim 60 comprising:

2 detecting the absence of signal from a distribution point to be removed
3 from the distributed network of distribution points;

4 determining a connectivity between distribution points remaining after
5 removing the distribution point detected with the absence of signal; and

6 providing each remaining distribution point with an indication as to
7 which distribution point in communication with the remaining distribution point each
8 information packet having a destination address specifying the new distribution point
9 is to be forwarded.

1 65. A method for routing packets as in claim 60 wherein the
2 destination distribution point comprises a host digital terminal transmitting packets
3 over optical fiber.

1 66. A method for routing packets as in claim 65 wherein
2 forwarding each packet to a destination subscriber unit comprises forwarding each
3 packet to an access point receiving packets over optical fiber and distributing packets
4 to each subscriber unit over a digital subscriber loop.

1 67. A method for routing packets as in claim 60 wherein
2 forwarding each packet to a destination subscriber unit comprises forwarding
3 through a VDSL service.

1 68. A method for routing packets as in claim 60 wherein the
2 distributed network of distribution points is further operative to route information
3 packets from an information supplier.

1 69. A method for routing packets as in claim 60 wherein
2 information packets are associated with an information channel, the method further
3 comprising receiving each information packet in a distribution center and forwarding
4 information packets to each subscriber unit in communication with the distribution
5 center and requesting the information channel to which the information packet is
6 associated.

1 70. A method for routing packets as in claim 69 wherein the
2 information packets comprise video information.

1 71. A method for routing packets as in claim 69 wherein
2 forwarding each packet to a destination subscriber unit comprises forwarding each
3 packet to an access point, the access point functioning as the distribution center.

1 72. A method for routing packets as in claim 69 wherein at least
2 one distribution point is functioning as the distribution center.

1 73. A method for routing packets as in claim 69 further
2 comprising:

3 receiving a request from a subscriber unit to access an information
4 channel;

5 requesting transmission of the requested information channel if no
6 other subscriber unit is receiving the requested information channel; and

7 noting that the requesting subscriber unit is receiving the requested
8 information channel.

1 74. A method for routing packets as in claim 73 wherein receiving
2 a request from a subscriber unit comprises determining that the requesting subscriber
3 unit is within the coverage area of a distribution center.

1 75. A method for routing packets as in claim 73 wherein receiving
2 a request from a subscriber unit comprises receiving a message from a subscriber
3 unit.

1 76. A method for routing packets as in claim 73 further comprising
2 transmitting a dummy address as the destination for the requested transmission of the
3 requested information channel.

1 77. A method for routing packets as in claim 73 further
2 comprising:

3 determining that a subscriber unit is no longer accessing the
4 information channel;

5 canceling transmission of the information channel if no other
6 subscriber unit is receiving the information channel; and

7 noting that the subscriber unit is no longer receiving the information
8 channel.

1 78. A distribution point for use in a communication system
2 comprising a plurality of networked distribution points, the distribution point
3 comprising:

4 at least one front end communication interface, each front end
5 interface in communication with an access point, the access point in wireless
6 communication with subscriber units currently assigned to the distribution point;

7 at least one back end communication interfaces, each back end
8 interface in communication with a back haul communication device, at least one back
9 haul communication device transferring packets with a back haul communication
10 device in another of the plurality of networked distribution points; and

11 an intelligent packet switching device operative to

12 (a) determine a destination for each received packet,
13 (b) determine if the destination is to a subscriber unit currently
14 assigned to the distribution point,

15 (c) send the packet to the destination subscriber unit if the
16 destination subscriber unit is currently assigned to the
17 distribution point,

18 (d) if the destination is not to a subscriber unit currently assigned
19 to the distribution point, determine if the destination is to a
20 subscriber unit currently assigned to any other distribution
21 point in the communication system, and

22 (e) if the subscriber unit is currently assigned to any other
23 distribution point in the communication system, identify
24 another distribution point in back haul communication with
25 the distribution point to which the packet should be forwarded
26 and forward the packet to the identified distribution point.

1 79. A distribution point as in claim 78 wherein at least one front
2 end communication interface is connected to an antenna, thereby permitting the
3 distribution point to be in wireless communication with at least one radio access
4 point.

1 80. A distribution point as in claim 78 wherein at least one front
2 end communication interface is in wireline connection with a radio access point.

1 81. A distribution point as in claim 78 wherein transferring packets
2 between a back haul communication device within the distribution point and a back
3 haul communication device in another of the plurality of networked distribution
4 points is a wireless transfer.

1 82. A distribution point as in claim 78 wherein transferring packets
2 between a back haul communication device within the distribution point and a back
3 haul communication device in another of the plurality of networked distribution
4 points is through a wireline connection.

1 83. A distribution point as in claim 78 wherein the intelligent
2 packet switching device comprises an asynchronous transfer mode switch.

1 84. A distribution point as in claim 78 wherein the intelligent
2 packet switching device comprises an Internet protocol router.

1 85. A distribution point as in claim 78 wherein the intelligent
2 packet switching device comprises an Ethernet router.

1 86. A distribution point as in claim 78 wherein the intelligent
2 packet switching device comprises a TDM switch.